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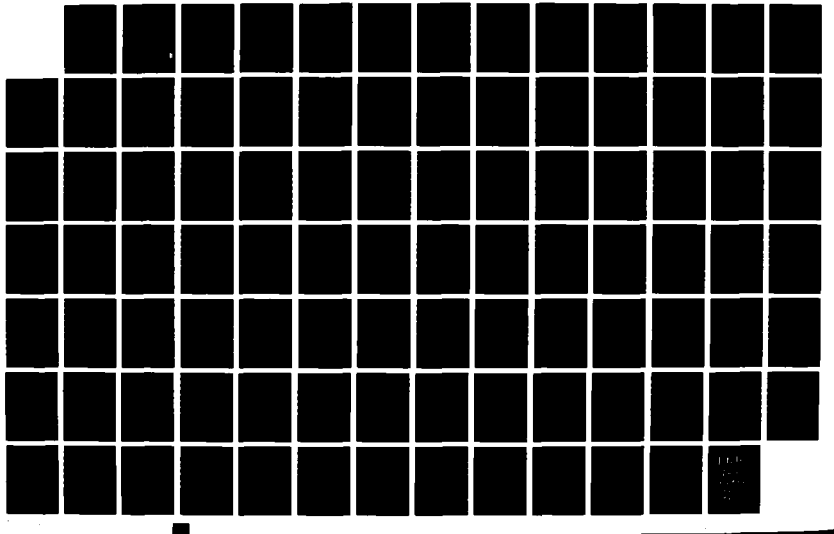

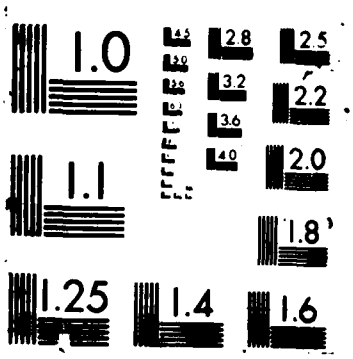
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THE EFFECT OF DISCOUNTING ON DEFENSE DECISIONS

THESIS

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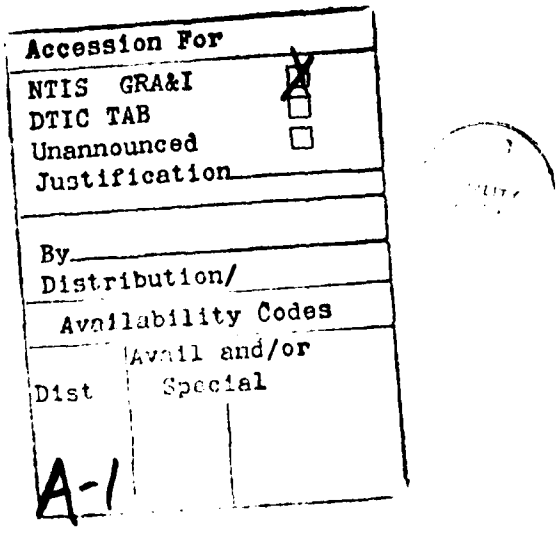

AFIT/GSM/LSQ/87S-5

THE EFFECT OF DISCOUNTING ON DEFENSE DECISIONS

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
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In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Systems Management

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Preface

The study presented here is an attempt to determine how discounting is used in the Air Force and what effect it has on the outcome of decisions. Several cost analysts, from various levels of management, were interviewed and several cases were analyzed to determine this. Hopefully this study will contribute to a better understanding of discounting and encourage its use.

I would like to express my deepest appreciation to Mr. Roland Kankey. Without his limitless patience and guidance I would never have completed this thesis. I am also deeply indebted to my husband, Paul, for taking care of our daughter, Cassandra, through her first month of life.

— Veronique M. D. Carstens

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Abstract

The technique of discounting is based on the premise that a dollar today is worth more than a dollar in the future. This is often referred to as the time value of money. This technique is widely accepted in the private sector; however, its use in the public sector has been repeatedly questioned. This thesis explores the use of discounting within the Air Force, specifically within the acquisition process. Several analysts were interviewed and several cases were reviewed to determine if discounting is being used and how it affected the outcome of decisions. In addition, the author provides a background behind the discount rate being used by the DoD, including a discussion on the social discount rate theories, the difference between net present value and internal rate of return, and a discussion on inflation.

THE EFFECT OF DISCOUNTING ON DEFENSE DECISIONS

I. Introduction

General Issue

With the ever increasing deficit, the advent of Gramm-Rudman and recent bad press concerning the costs of past weapon systems, the cost of new weapon systems has become a major concern to the Air Force. In fact, costs are now a major decision criteria used to determine whether or not to develop a new system and what type of system to develop. Air Force Regulation (AFR) 800-11 states,

> Cost is a parameter equal in importance to technical performance, supportability, and schedule requirements. The full impact of life cycle costs will be considered in decisions associated with the selection, design, development, production, modification, use and support of defense material [12:1].

How these costs are calculated can significantly influence the outcome of these decisions. Air Force directives and regulations suggest that the present value between alternatives should be considered for all capital expenditures. Capital expenditures are defined as expenditures that result in assets (31:390). At base level, policy mandates that present value be used. For example, all military construction projects must have an economic analysis performed before they can be funded. An economic analysis

systematically examines and relates costs, benefits, and risks of various alternatives under consideration. "Fundamental to economic analysis is the concept of present value" (11:2). However, it is not clear if the present value of costs is being used in the acquisition of new weapon systems. Using present value, as opposed to constant dollars, to compare costs could reverse the outcome of some decisions. These decisions may significantly influence the design characteristics of a new system or may determine whether or not a weapon system itself should be purchased.

Specific Problem

As stated in Air Force Regulation (AFR) 178-1):

> Present value calculations allow comparison of different dollar amounts received or expended during different time periods. The underlying notion is that money received today is worth more than the same amount of money received sometime in the future--This is the "time value of money." The interest rate (discount rate) represents the price paid for borrowing money. Discounting (the inverse of compounding) is the technique used to determine the present value of future cash flows. It is the sum of discounted cash flows during the life cycle of an alternative which determines the cost of that alternative in an economic and financial sense [11:2].

Life cycle cost is defined as the total cost associated with a weapon system throughout its useful life. "It includes the cost of development, procurement, operation, support, and disposal" (12:1). When comparing alternatives for decision purposes, life cycle costs are

used. Upon initial investigation, the use of discounting to determine these costs indicates that it might tend to favor the purchase of less reliable weapon systems. This can be explained by the fact that a more reliable weapon system will usually require greater investment costs with the savings from these investments realized in the future. These savings, when discounted, will be worth less in current dollars and may not offset the increased initial investment costs of the new system. On the other hand, a less reliable system will generally cost less to purchase today and will have greater maintenance costs in the future. If costs were left in constant dollars, these future expenses may greatly outweigh the lesser investment costs. However, under discounting these costs would be reduced when stated in present value and this greater total life cycle cost may not be evident. This study will explore the effect discounting has on decisions made during the acquisition process.

Justification

Air Force regulations and directives do not give specific guidance as to when discounting is appropriate in the acquisition process. Because of this, a controversy over when discounting should be used has arisen. Some managers feel discounting should be a tool used in all capital expenditure decisions. Others feel that the use

of discounting in the acquisition process could prevent the purchase of needed systems or lead to the purchase of less capable systems. In addition, other controversies such as what type dollars should be discounted, constant versus current, and what discount rate to use, have also arisen. This thesis will address the use and potential impact of discounting in the acquisition process.

Scope

Discounting is used in all agencies of the Executive Branch of the federal government. However, only the use of discounting within the Air Force will be addressed in this study. More specifically, this study will concentrate on the use of discounting in the acquisition of new weapon systems.

Limitations and Assumptions

This thesis will only address the use of discounting in the acquisition process. It will not look at military construction projects or productivity enhancement projects.

The question of whether or not nonquantifiable benefits should be discounted will not be addressed. This is a very controversial subject and is beyond the scope of this thesis. When the term "benefits" is used in this thesis it refers to quantifiable benefits such as savings.

It is assumed that the reader is familiar with discount factors and tables and the basic arithmetic behind discounting. Therefore, only the results of the cases analyzed are shown. The actual calculations used to reach these results have not been included.

Background

Discounting--the technique by which resources produced or consumed in different time periods can be made commensurable--is an accepted practice among economists and is a standard technique in management accounting (32:1). The applicability of discounting in private business has been well established; however, its use in the public sector has been less clearly defined and has been the subject of considerable debate.

> The most often addressed issues center on whether or not the discount methodology was applicable to public investment decisions and if so what rate (or range of rates) would lead to the best decisions [2:9].

The Office of Management and Budget (OMB) currently supports the use of a 10 percent discount rate throughout the federal government. One notable exception to this policy are discount rates used in lease-versus-buy analyses. For these analyses the discount rate used is the current interest rate on new issues of U.S. Treasury securities with maturities most nearly equal to the term of the lease (26:4).

Even though the use of discounting has been mandated in the public sector, the question of whether or not it is appropriate is still worth pursuing for two reasons. First, the very size of the federal budget forces the issue. Currently the defense budget makes up approximately 30 percent of the federal budget. Each year crucial decisions must be made involving billions of dollars to be spent both in the present and in the future. The sheer magnitude of dollars involved necessitates that the funds be appropriated to the most efficient and effective projects possible (2:10). Since not all programs can be funded, they must be analyzed and ranked. Discounting can play a major role in this process and, therefore, should be thoroughly understood to prevent the misallocation of funds.

The second reason for studying the use of discounting in the public sector relates to the issue of public versus private investment. "Projects which are undertaken in the public sector have an indirect impact on potential investments under consideration in the private sector" (2:10). Every time a public project is funded, revenues must be generated. This is usually achieved through taxes. As taxes are increased less is available for private investment. According to Shishko, "Many economists believe that many projects which would be rejected by the private sector are funded by the Government because an inappropriate discount rate is used" (32:20). A countering argument is that

the government can use a social discount rate which is not necessarily the same as the rate being used by industry. The social discount rate theories will be discussed in the next chapter.

Within the context, this thesis will attempt to present an objective discussion of the important issues pertaining to discounting in the defense department.

Definitions

In order to proceed, the reader must have a clear understanding of the different dollars referred to in this study and an understanding of the concept of discounting itself.

1. Constant Dollars: A phrase reflecting the dollar "purchasing power" for a specified year. An estimate is in constant dollars when prior year costs are adjusted to reflect the level of prices of the base year, and future costs are estimated without inflation [8:A-15].

2. Current Dollars: Dollars which reflect purchasing power current to the year the work is performed. Prior costs stated in current dollars are the actual amounts paid out in these years. Future costs stated in current dollars are the projected actual amounts which will be paid. Also sometimes referred to as actual dollars, then year dollars, inflated, or escalated dollars [8:A-25].

3. Discounted Dollars: Future dollar streams adjusted for the time value of money.

4. Discounting: A technique for converting forecasted amounts to economically comparable amounts at a common point in time, considering the time value of money. The time value of money is considered by computing present value costs. Present value costs are computed by applying a discount rate to each year's cost in a cost stream. Discount rates are usually

developed to closely approximate the current cost of money in the financial marketplace. The purpose of discounting is to determine if the time value of money is sufficiently great to change the ranking of alternatives--a ranking that has been established as the basis of all other considerations [8:A-29].

II. Literature Review

Introduction

The basic assumption underlying the concept of discounting is that benefits realized in the near future are valued higher than those realized in the distant future. In addition, costs which are incurred in the near future seem greater than those costs which will be incurred in the distant future. Discounting is the technique of making these future benefits and costs comparable to present benefits and costs. Staats noted the present value of these future benefits and costs can be compared to benefits and costs realized now. He said, "the numerical standard used in making these intertemporal comparisons is called the discount rate" (34:24).

Capital expenditures generally involve a series of annual costs and a flow of benefits over time. Different alternatives will have different costs and benefits and the timing of these costs and benefits will also differ.

> Calculation of the present values of costs and benefits, through discounting makes possible a comparison of costs and benefits, usually expressed in terms of a ratio of benefits to costs, which gives consideration to the time periods in which benefits will be realized and costs incurred [34:24].

The decision maker can compare different alternatives simply by comparing their total present value. Discounting

is also helpful in cases where benefits can't be quantified in terms of dollars. Here, the decision maker can compare the present value of the costs and decide whether or not the benefits are worth their expense.

Although discounting is a very powerful tool, it is not always valued in the decision-making circles within the Air Force. "The concept is often ignored, or employed by rote. Frequently there is confusion as to what analyses that employ discounting really mean" (29:4). Not all managers feel that discounting is always appropriate. In addition, there is considerable controversy over what discount rate should be used. These controversies will be examined next.

Social Discount Rate Theories

"The question of which discount rate is most appropriate for public investment analysis has been an issue of debate among economists for decades" (7:8). A Rand Report issued in 1976 (32) contends that if an economy has a perfect capital market, the government need only look at the interest rate observed in the market to determine the discount rate it should use. However, the marketplace is not perfect and several interest rates can be observed at any one time.

> This fact not only makes any single observed rate inappropriate, it also contributes to the controversy surrounding the selection of an appropriate surrogate for the perfect market rate [7:8].

There exist two schools of thought regarding the calculation of the discount rate to use when evaluating public investments: the social opportunity cost of capital and the social time preference position.

The opportunity cost of capital position states that government should seek to maximize the well being of the nation by maximizing the national wealth. They contend that funds diverted from the private sector for public investments must yield at least as much as they would if they had been left in the private sector (5:4). This position presumes that the government should act like a private firm and accept all investments with returns which exceed its costs of borrowing.

Although the concept of opportunity cost of capital can be stated simply, the measurement of this rate is rather difficult. Currently, there are three approaches to arriving at this rate with three different sets of assumptions. The first position argues that private sector activity is displaced and its returns foregone when public investments divert real inputs from the private to the public sector (2:23). To measure the discount rate one must use the corporate before-tax rate of return on investment. Jacob Stockfisch used this approach to determine his estimation of the opportunity cost of capital (35). A second view considers the costs which are imposed on the private sector when the federal government finances its

expenditures through borrowing. Public borrowing tightens capital markets and restricts credit to other sectors of the economy (2:24). With this set of assumptions the social opportunity cost of capital is the weighted average of the after-personal-income-tax rate of return to savers and the pre-corporate-income-tax cost of capital. Arnold Harberger used this approach in his research to determine the appropriate discount rate (19). The third and final approach maintains that federal expenditures are paid for by the taxes through which they are financed (2:24). A weighted average of various consumer borrowing rates is used to measure the discount rate. Robert H. Haveman used this assumption in his research (20). Regardless of which set of assumptions is used, each approach is measuring the productivity of funds employed in the private sector (29:4).

In opposition to the opportunity cost of capital approach are those who advocate a social time preference approach. This concept states that opportunity costs do not properly account for the desire of society to provide for the well being of the world, putting higher value on consuming resources today than postponing consumption today in order to ensure consumption at some future time (5:3). To overcome this tendency, proponents of this position state that more monies should be diverted (by direct or indirect taxes) from the private sector into the public sector. "This increase in public sector investment can be

accomplished by the government's use of a discount rate lower than the observed private sector rate when evaluating investments" (5:3). In so doing, the government would approve projects which ordinarily would not be undertaken using the private sector rate of return. Thus, future generations would reap the benefits from projects (such as dams or improved defense systems) funded by the current generation. This position, however, raises other questions, namely, by how much and by what monetary instruments should the private sector discount rate be lowered. According to Russell,

> The net-of-tax rate on government bonds is often viewed as a good measure of the pure time preference rate. The logic is that in willingly foregoing current consumption with their money in order to get the prevailing after-tax rate of return on these bonds, investors in government bonds are revealing their pure time preference rate [29:4-5].

In an ideal world with no taxes or market imperfections the social opportunity cost of capital discount rate and social time preference rate would be equal. Unfortunately, in the real world, taxes, differential cost of information and monopolies act to create a difference between these two rates (32:3). Although it appears these two theories approach the measurement of the discount rate from two totally different perspectives, there is some overlap. As mentioned before, Herberger's calculation of the social opportunity cost of capital included the after-personal-income-tax rate of return on savings. Russell

stated that this was a good measurement for the pure time preference rate. To complicate matters more, some researchers have argued that although a dollar of government investment may displace some private capital, in the long run the flow of services from the government project will in fact increase private capital (32:5). If using the assumption that a dollar of government investment will generate a dollar of private revenue then the appropriate discount rate would be measured by the pure time preference approach. However, if using the assumption that a dollar of government investment displaces a dollar of private capital, one would use the opportunity cost of capital approach to solve for the discount rate (32:5).

This unresolved dispute between these two approaches causes a serious practical problem.

> The pure time preference rate (measured as the net-of-tax rate on government bonds) will always be less than the opportunity cost of funds (measured as the corporate rate of returns on investment gross of taxes) [29:5].

The outcome of any decision employing a discount rate can be greatly influenced by the value of the discount rate used. An illustration of how the discount rate can influence the outcome of present value calculations is demonstrated in the following example. A military construction project requires an initial outlay of 10 million dollars and additional outlays of 10 million a year for five years.

The present value of this project using discount rates of 5, 10 and 20 percent are 53.9, 47.9 and 43.1 million dollars respectively (5:2-3).

In 1968 the U.S. Congress Joint Economic Committee, Subcommittee on Economics in Government undertook a detailed review of what social discount rate to be used throughout the federal government. A detailed survey revealed that less than half the agencies examined used discounting in evaluating their fiscal programs. In addition, it was revealed that the discount rates used by the agencies who employed discounting, varied from 3 percent to 12 percent. A variety of rationales were used to justify these different rates. It was obvious from this review that there were no set policies as to when discounting should be used in the federal government and what was considered an appropriate rate (34).

In an attempt to rectify this situation the Office of Management and Budget (OMB) published Circular A-94, Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits, in 1972. This circular supported the opportunity cost of capital approach as opposed to the pure time preference approach for measuring the discount rate. It also provided a standard discount rate to be used in evaluating costs and/or benefits of government decisions concerning the initiation, renewal or expansion of programs and projects. The discount rate is suggested for use in

internal planning of agencies but is required for program analysis submitted to OMB in support of legislative and budget programs. The 10 percent rate was selected because it ". . . represents an estimate of the average rate of return on private investment before taxes and after inflation" (25:4). Therefore, one can conclude that even though there is no consensus among public finance economists, the OMB has chosen to use the opportunity cost of funds approach to arrive at the discount rate.

Net Present Value and Internal Rate of Return

Once a discount rate has been chosen one must then choose the discounting technique in which to employ it. There are two basic discounted cash flow techniques that are used to analyze capital alternatives: net present value (NPV) and internal rate of return (IRR) (21:17). These techniques are used hand in hand with capital budgeting. Capital budgeting is the process of making investment decisions under fiscal constraints. Usually managers are faced with more projects to undertake than money available to fund them. Therefore, projects must be rank ordered. NPV and IRR are discounting techniques that enable managers to prioritize projects. The ultimate objective of capital budgeting is to undertake projects that will maximize the value of the firm, or in this context to maximize the effectiveness of the Department of Defense (27:70).

In the past it was common to use only the payback method to evaluate proposals. This method estimates the number of years required to recover the initial outlay of funds for any given project. Although the payback period is very easy to calculate, it has two major drawbacks. First, it ignores returns beyond the payback period. Second, it ignores the time value of money; in other words, it does not use discounted dollars (27:70).

> In addition, the payback method fails to consider the scale effects of different projects, making this approach inappropriate when developing an ordinal ranking of proposed acquisition and funding priorities [30:75].

Today, internal rate of return (IRR) and net present value (NPV) are used to evaluate projects.

The internal rate of return (IRR) is the discount rate (expressed as a percentage) that equates the present value of the anticipated net cash flows to the initial project investment. "The internal rate of return is sometimes described as the maximum interest rate an organization could pay for the cash invested in a project without losing money" (23:710). The internal rate of return can be found through solution of the following equation for r:

$$\text{Initial Investment} = S_1/(1+r)^1 + S_2/(1+r)^2 + \ldots + S_n/(1+r)^n \qquad (1)$$

where

S = Predicted net cash inflow

r = Internal rate of return

n = Life of the investment

Solution usually results in a unique discount rate r where equality holds [23:714].

This technique takes into account returns over the entire project life and the time value of money; however, it does not always maximize the value of the firm (27:70).

The net present value also takes into account all project returns and the time value of money. Under this technique, all project cash flows are discounted at the firm's cost of capital and then the cost of the project is then subtracted. If the resulting NPV is positive the project is accepted (27:70). The Net Present Value can be found through solution of Equation (2).

$$NPV = (S_1/(1+r)^1 + S_2/(1+r)^2 + \ldots S_n/(1+r)^n) - (\text{Initial Investment}) \quad (2)$$

where

NPV = Net present value

S = Predicted net cash flow

r = Minimum required discount rate

n = Life of the investment (23:710)

In private industry both IRR and NPV methods are used and will lead to the same investment decision when evaluating independent projects. However, this is not the case when evaluating mutually exclusive alternatives. "Two investments are mutually exclusive if the acceptance of one automatically causes the rejection of the other" (23:764). There are three situations where these two approaches may give contradictory results.

The first situation involves two or more mutually exclusive projects equal in size but with different cash flow timing. This is illustrated in Table 1. Although both projects are equal in size, the timing of their cash flows are totally opposite. Project A throws off the majority of its cash flow early in its life, while Project B produces the majority of its cash flow later in its life. The NPV and IRR can be depicted graphically in Figure 1.

TABLE 1

COMPARATIVE DATA FOR PROJECTS A AND B (27:71)

	(In millions)	
	Project A	Project B
Initial Cost	-10.0	-10.0
Cash Flow - Year 1	5.0	1.0
Year 2	4.0	2.0
Year 3	3.0	4.0
Year 4	2.0	5.0
Year 5	1.0	6.0
Return on Investment	20.0%	17.0%

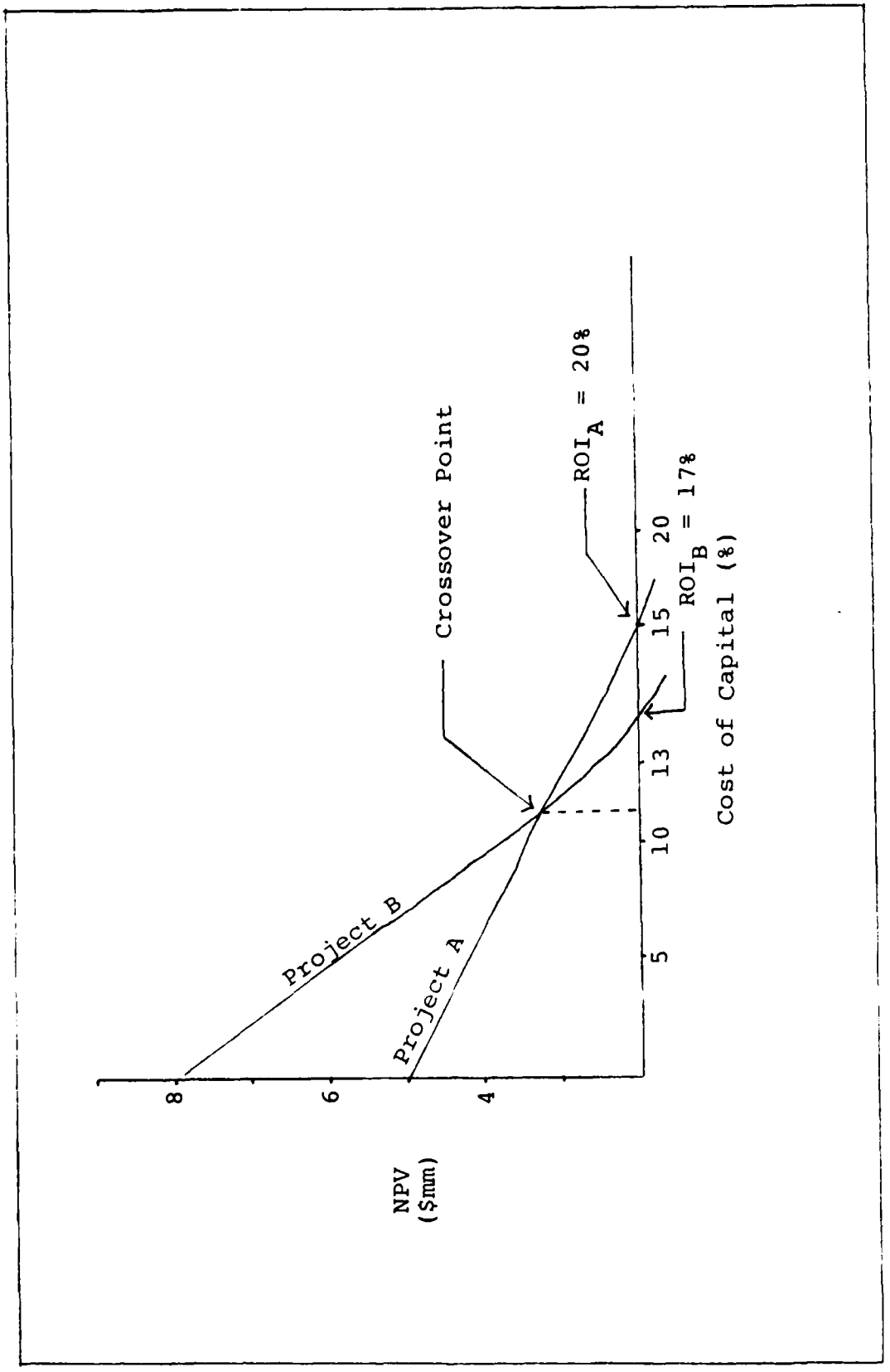

Fig. 1. Graph of NPVs for Projects A and B (27:72)

Using the IRR, Project A will always be chosen. This is because the IRR is always computed at NPV equal to zero. If, on the other hand, the NPV technique was used, the choice between Project A and Project B would be dependent on the discount rate used. At rates higher than 13 percent, Project A would have a higher NPV and would be chosen. At rates below 13 percent, the opposite is true. Thus, if the cost of capital were less than 13 percent, the IRR decision to accept Project A would be the wrong choice because it does not maximize the value of the firm (7:4). This example illustrates the following conclusion:

> Discounting of cash flows severely penalize long term projects where incomes are further into the future, and the higher the cost of capital, the more severely the project is penalized [27:22].

The second situation that may lead these techniques to recommend contradictory results, occurs when the size of two mutually exclusive projects are different. To illustrate, consider two projects with a life of one year and the cost and cash flows shown in Table 2. Although Project A has a higher IRR, its NPV is less than Project B simply because it is a smaller project. Ideally, in a situation like this, the firm should invest in two Project A's. "The IRR ranking favors short-lived projects with high internal rates of return over long-lived projects with lower rates of return" (23:769). However, this technique tends to ignore almost equal returns on larger amounts of money.

TABLE 2

COMPARATIVE DATA FOR PROJECTS A AND B
WITH DIFFERENT SIZES (7:8)

	Project A	Project B
Initial Cost	-1000	-2000
Return After One Year	1200	2300
IRR	20%	16%
NPV (Discounted at 10%)	90.91	109.09

Stated differently, it's better to receive a 50 percent return on 10 thousand dollars than a 100 percent return on $10; however, the IRR technique will not point this out (27:71). Conversely, the NPV approach does not consider the size of the investment. It will not distinguish between a $10,000 investment that produces a $2,000 NPV, from a $20,000 investment that also produces a $2,000 NPV. To rank such projects a profitability index must be calculated.

$$\text{Profitability Index} = \frac{\text{Present Value of Net Cash Inflows}}{\text{Investment Cost}} \qquad (3)$$

(33:932)

In both situations described above, there are cash flow differentials. In the first example, project A throws off more cash in the early years and in the second example, project A requires less initial investment. IRR and NPV

both make the assumption that these cash differentials can be reinvested elsewhere. However, the assumptions governing the rate at which these investments are made, differ and is the cause for the contradictory results between the two methods. The NPV method implicitly assumes that the opportunity exists to reinvest these cash flows at the cost of capital, while the IRR method implies the opportunity to reinvest at the IRR (3:406). Economists generally conclude that the cost of capital implicit in the NPV method is the better assumption.

> The IRR method implicitly assumes reinvestment at the internal rate of return itself. Given a constant expected future cost of capital and ready access to capital markets, this assumption is incorrect [3:408].

The third situation which causes discrepancies between the two techniques, is when some future cash flows are negative, as shown in Table 3. This project actually has two IRR values, 10 percent and 25 percent. Under these conditions, it is impossible to make a decision on how a project should be ranked (7:6).

TABLE 3

NEGATIVE CASH FLOWS (7:6)

	Year 1	Year 2	Year 3
Cash Flow	-72,727	170,909	-100,000

All these conditions can occur when considering DoD projects. The question one must ask is which technique should be used during the prioritizing process.

> On a theoretical basis [the] NPV technique is superior because (1) IRR favors short duration, fast cash throw off projects in all economical environments, where NPV tempers the project evaluation based on the actual cost of capital; (2) the NPV reinvestment assumption is more realistic; (3) an IRR analysis may have multiple solutions; and (4) the return of incremental investment for projects of different sizes is not normally considered [27:73].

In addition, the NPV technique can be used to discount cost streams. "This occurs in cases where benefits resulting from an investment are difficult or impossible to quantify" (7:6).

AFR 178-1 tends to support this logic since it specifies the use of the present value approach when preparing an economic analysis. The major drawback to using the NPV approach is that results from this technique are very dependent on the discount rate. This in turn relates back to the controversy already discussed, mainly how one should arrive at this rate.

Inflation

The steps for evaluating alternative investments are the same whether the evaluation is being done for the public or private sector. First, a projection of cash flows, both in and out, must be developed for each alternative under consideration. In addition, the timing

of these cash flows must be determined. Basically five quantities must be estimated:

a. The amount of initial capital outlay and any later investments.
b. The amount of cash (if any) that will be available at the end of its productive life (i.e., salvage value).
c. The net increase in cash flows (if any) expected from the investment.
d. The times when the above outflows and inflows are expected to occur.
e. The expected productive life of the investment [2:36].

Inflation, defined as an increase in the general price level of goods, can significantly affect the overall rate of return and, therefore, influence the decisions made between alternatives (5:44). Expressing overall rates of returns in constant dollars during periods of inflation tends to decrease these values. For example, suppose a person invests 100 dollars for a year in hopes of receiving a 20 percent increase in actual spending power. The rate of inflation is set at 10 percent. Considering inflation only, 100 dollars today is eqivalent to 110 dollars in one year. If the individual were to increase his real buying power by 20 percent, he must earn 32 dollars with his initial investment of 100 dollars. This earning would increase his actual buying power at the end of one year from 110 dollars to 132 dollars or 20 percent. Although the individual appears to have earned a return of 32 percent on his initial investment, this 32 percent is a nominal rate (with inflation) and must be adjusted for inflation (5:44).

To adjust nominal rates to real rates the following formula can be used:

$$1 + r = (1+R)(1+I) \qquad (4)$$

where

f = nominal rate of return

R = real rate of return

I = annual rate of inflation (5:45)

Solving equation (1) for the real rate of return (R):

$$R = (r-I)/(1+I)$$

For our example, we have,

$$R = (.32 - .10)/(1+.1) = .22/1.1 = .20$$

This 20 percent represents the real rate of return.

As mentioned before, OMB Circular A-94 specifies that a 10 percent discount rate should be used to discount future period cash flows. Specifically, this circular states:

> All estimates of costs and benefits for each year of the planning period should be made in <u>constant</u> (without inflation) dollars. . . . Estimates may relfect changes in the <u>relative</u> prices of costs and/or benefit components, where there is reasonable basis for estimating such change, but should not include any forecasted change in the general price level during the planning period [25:3].

Although this suggests that inflation does not need to be considered, the Department of Defense acknowledges that inflation is often important when costing multiyear programs. DODI 7041.3 directs, "When inflation is considered important to the conclusion, a second computation will be made in terms of current (inflated) dollars." This can be considered a sensitivity analysis. Three methods are suggested for calculating these costs:

> a. Inflate the cost streams first, then introduce the discount rate.
> b. Discount the cost streams first, then introduce the inflation rate.
> c. Apply a joint discount/inflation rate in a single calculation [13:10].

Regardless of which of these methods is employed, the adjusted net present values in all three calculations will be the same.

According to Russell, ambiguity is introduced because OMB Circular A-94 reserves the option to look at the 10 percent discount rate as either a real (no inflation) or nominal (with inflation) rate. "If the discount rate is nominal (with inflation) the cash flows must be expressed in inflated dollars for the present value analysis to be correct" (29:5). Using an example presented by Russell in his article "Discounting in Defense Decision Analysis" this point can be illustrated.

Given two options, a multiyear buy and a traditional annual buy, the traditional annual buy is cheaper up front

but more expensive down stream (see Table 4). By contrast, the multiyear buy has a higher start-up cost and has savings down stream.

TABLE 4

ANNUAL BUY VERSUS MULTIYEAR PROCUREMENT CASH FLOW EXAMPLE (29:5)

	Year t	Year t + 1	Year t + 2	Year t + 3	(In millions) Total
Annual Buy	$100	$90	$90	$90	$370
Multiyear	147	75	70	70	362
Multiyear Savings	-47	15	20	20	8

Evaluation of the Multiyear Savings

Absolute Dollars	$ 8.0m
NPV (constant dollars) at 10%	$-1.74m
NPV (5% inflated dollars) at 10%	$ 2.9m

In absolute dollars the multiyear alternative will save eight million dollars over the annual buy. However, if you consider the time value of money, the dollar savings realized in the outer years are worth less than the dollars being spent presently. Using a 10 percent discount factor the cash flow and savings would look as shown in Table 5. When the time value of money is taken into account, the savings generated in the out years, by the multiyear alternative, do not make up for the higher initial

TABLE 5

COST COMPARISON FOR ANNUAL BUY VERSUS MULTIYEAR EXAMPLE

	Year t	Year t + 1	Year t + 2	Year t + 3	(In millions) Total
Annual Buy	$95.40	$78.03	$70.92	$64.53	$308.88
Multiyear	140.24	65.03	55.16	50.19	310.62
Multiyear Savings	-44.84	13.00	15.76	14.34	-1.74

investment. Therefore, one would conclude that an annual buy would be more effective and that the future savings are not sufficient to offset the time value of money.

Finally, if a 5 percent inflation factor is introduced to the out year savings and then discounting is applied, the net savings would be $2.93 million. With these conditions multiyear procurement would be recommended (29:5).

Due to the latitude of interpretation of OMB Circular A-94's 10 percent discount rate, managers might feel a temptation to manipulate decisions. Congress has multiyear program (MYP) approval authority. Recently there has been a push to decrease MYPs since this is part of the noncontrollable budget. When a MYP is approved, all funding for present year is approved as well as all out year costs.

If Congress does not make the investment in the MYP for a weapon system, it can take the difference in cost

> between the MYP and regular procurement and apply it to (invest it in) some other budget item, whether within the DoD budget or in a social program [21:18].

Managers must pay particular attention to programs that extend over several years since they can be approved on inflationary savings alone. This would lead to the less than optimal distribution of DoD funds.

Use of Discounting Within DoD

Having discussed the various controversies over the technical aspects of discounting, the next question that must be addressed is whether or not discounting should be used by the defense department in the decision-making process. At one end of the spectrum, Cdr Rolf H. Clark contends that there is no place for discounting in DoD because managers are working under fiscal constraints. On the other end, Dr. Richard Thaler argues discounting plays an integral part in decision making. These two views will be examined in detail.

Commander Rolf H. Clark contends that there are three basic reasons for discounting future costs. These reasons include risk, inflation, and desire to determine productive capacity or real rate of return on investment funds. The latter is the most important reason, since rates of return are used to evaluate the best alternative in the decision-making process. For example, when a corporation wants to make a capital expenditure, it

ultimately obtains the funds from consumers. "If the rate of return on corporate investment is known, it gives some indication of how willing consumers are to invest funds rather than to consume them" (4:13). If the corporate rate of return is 10 percent and people are investing in the company, this says that as long as the rate of return stays at 10 percent consumers are willing to invest rather than consume their dollars. Since the government also gets its capital from the consumer through taxes, it follows that the government should not invest in a capital expenditure unless the rate of return equals that of the private sector; in this example, 10 percent.

> OMB Circular A-94 recognizes this relationship between public and private investment. The A-94 requirement to discount cost streams using a 10 percent rate is based on the argument that 10 percent "represents an estimate of average rate of return on private investment, before taxes and after (adjusting for) inflation" [4:14].

Nevertheless, managers within the Department of Defense, often find discounting inconsistent with the fiscal guidance constraints under which they must formulate their programs. This leads into the relationship between discounting and decentralization.

"Decentralization is the process whereby a parent organization controls its components through the imposition of financial constraints" (4:14). In a corporation these financial constraints usually come in the form of fiscal guidelines and are stated in terms of investment versus

profits. "For example, a corporation could direct a division to invest in projects that provide at least a 10 percent rate of return" (4:14). However, one can immediately see that the Department of Defense is not out to make a profit; therefore, returns must be stated in terms of investment versus security returned.

Consequently, decentralization policies for the Air Force must be stated in these terms and not in terms of profits. There are two ways to state these policies:

> [1] Minimize cost subject to effectiveness constraints (decide what is needed and then buy the capability at least cost)
> [2] Maximize effectiveness subject to fiscal constraints (decide how much can be spent and then buy the best possible system for the money) [4:14].

These two policies can lead to very different decisions. The first statement emphasizes system requirements more than cost. In other words, the government is willing to pay whatever price is necessary in order to obtain the new weapon system. The second statement, however, emphasizes cost more than system requirements. One could almost say the government buys what it can afford and not what it really wants. Most recently fiscal policy has been stated in terms of the latter statement. Clark states that the use of discounting is dependent on the decentralization policy being used.

> The discounting argument hinges critically on the question of decentralization. If a resource sponsor is using the criterion of minimizing cost subject to

> required effectiveness levels, then discount rates are required to arrive at an optimal solution and discounting is proper. However, if the manager is maximizing effectiveness subject to fiscal constraints, then the requirement to discount costs is improper, unless one also discounts the annual budgets to be provided. But if both the costs and the budget are discounted, then it makes no difference what discount rate is used; discounting becomes irrelevant [4:16].

To illustrate this point, suppose that a manager is faced with a fixed budget for next year of $100. If a project's next year cost is $110, under Clark's theory it cannot be undertaken even if the discount rate is 10 percent. Although discounting this cost at a 10 percent rate will give it a present value of $100, it will still require $110 to fund it next year and only $100 is available. Clark would contend that to correctly evaluate this situation both the budget and the project cost should be discounted at a 10 percent rate. But if both the budget and project cost are discounted to present values, the project cost still will not fit the budget and the project would be rejected.

Thus, with this argument, it can be concluded that discounting is not appropriate if the defense manager is under fiscal constraints. Another argument against discounting is the fact that discounting can be easily, even deliberately, misused. If a manager favors one alternative over another, he can make this preferred alternative seem less expensive by simply deferring costs to future years. The discounting effect will give the false impression that

costs are less when in fact they have been discounted to bring them to their present value (4:17).

In direct opposition to Cdr Clark's viewpoint that discounting is inappropriate under constrained budgets, Dr. Thaler argues that discounting should be used. Dr. Thaler contends that the discount rate simply indicates the time value of money, which in turn is determined by opportunity costs. Opportunity costs are the product of circumstances. For example, if faced with the choice of investing $200 today on project A or $205 a year from now on project B, which would be chosen? Cdr Clark would say invest in project A. Dr. Thaler, on the other hand, would say it depends on what other opportunities exist for the $200 today. If this money can be invested in a 5 percent savings account it will earn $10 in a year. Under these conditions project B should be chosen (36:2).

Cdr Clark's view not to discount, is the same as saying the discount rate is zero. This in turn indicates that there is no opportunity costs between alternatives: Thaler rejects this hypothesis. Although DoD managers cannot earn bank interest on funds, they do have other alternatives. Cost-saving expenditures, conservation measures, and preventive maintenance all have positive rates of return. Thaler contends that the only time opportunity costs would equal zero is if the DoD had a totally

unconstrained budget. Under these conditions the DoD could undertake every project with a positive return.

As discussed previously, determining the correct opportunity cost can be difficult. However, Thaler states, ". . . the inability to calculate the correct discount rate with accuracy is no excuse for using a zero rate" (36:6). He agrees with the OMB's use of a 10 percent discount rate and cites two reasons for discounting.

> First, a specific discount rate is needed because decisions tend to be made in isolation. . . . Further, it is much too costly to determine all of the alternative uses for any particular amount of money. Thus the discount rate is a simple rule of thumb which helps make individual decision making easier and more effective. Second, the use of a positive discount rate does not imply that next year is less important than this year. It merely represents the rate at which this year's dollars can be converted into next year's dollars [36:5].

Thaler summarizes his view as follows:

> (1) Not discounting is the same as using a zero discount rate. (2) Using a zero discount rate is only correct if the opportunity cost of money is zero. (3) Fixed budgets do not imply that opportunity costs are zero. Therefore, (4) even in a world of fixed budgets, costs should be discounted [36:9-10].

Between these two extreme views concerning the use of discounting, is the view held by Blandin and Frederiksen. In their article, "The Role of Discounting in Problems of Choice," they state that the primary function of discounting is to provide additional information to aid the decision maker in the difficult problems of choice. Unlike Clark and Thaler, who suggest that discounting provides the solution

between different alternatives, Blandid and Frederiksen believe discounting does not provide the solution but just additional information. In their view, discounting is an aid and not a requirement.

"Discounting does not decide questions of feasibility; instead, it provides information on preferability" (1:13). To illustrate this point, recall Clark's example of a fixed budget of $100 next year. Suppose a project under consideration will cost $101 next year. According to Blandin and Frederiksen, discounting in this case will not make a difference because regardless of the rate used the project will still cost $101 next year. Since the budget is fixed at $100 this project is and will remain infeasible.

Discounting is useful in evaluating different feasible alternatives. It can reduce different cost streams, over time, to one number (present value). This single number can be compared between alternatives. If cost is the most important issue, the alternative with the least total cost will be chosen. However, cost is not necessarily the only decision criterion. Different alternatives often have different levels of effectiveness. If the goal is to maximize effectiveness, the feasible alternative with the highest level of effectiveness will be chosen. This may not be the least cost alternative. On the other hand, J. E. Green of the United Kingdom Ministry of Defence,

indicates the highest unit effectiveness or highest system effectiveness does not necessarily equate to the highest force effectiveness when buegets are constrained (16:39).

Blandin and Frederiksen also point out that the DoD budget is not as constrained as Clark hypothesized. It is not uncommon to reprogram monies. In addition, the budgeting cycle allows ample opportunity for managers at all levels to lobby for increased funding. During the budget formulation and execution process many value-laden trade-offs must be made. "These judgments, in turn, hinge critically on the relative comparison of costs and benefits over time among the many alternatives" (1:15). Discounting allows managers to systematically and objectively evaluate these alternatives to better allocate given funds.

III. Methodology

Constructive interviews were conducted with managers from Air Force Logistics Command, Air Force Systems Command and Air Staff. The purpose of these interviews was to determine how discounting is actually being used in the field and its impact on decisions. These practices were then compared to the governing regulation and policies to see if any differences existed. If any differences were uncovered the reasoning behind them was explored. The following question format was used in conducting the interview.

I am Veronique Carstens from the current cost analysis class at the Air Force Institute of Technology. I am working on a research project dealing with the use and impact of discounting on DOD decision making. You have been identified as a source of information on this subject. May I ask you a few questions?

1. What is your name?

2. What is your job position?

3. Does your job entail performing or reviewing cost estimates for weapon systems or subsystems?

4. Is discounting used to evaluate alternatives?

5. Are operating and support costs considered when deciding among alternatives?

6. Are these operating and support costs discounted during this comparison?

7. Are decisions made based on the constant dollar comparison or present value (discounted costs) comparison?

8. Does discounting effect reliability and maintainability decisions on new weapon systems?

9. What discount rate is used?

10. Do you discount constant or current (inflated) dollars?

Several actual cases were analyzed to demonstrate the use of discounting in the acquisition process and to see if, in fact, discounting affected the outcome.

IV. Findings

Introduction

Most people would agree with the statement, "a dollar today is not worth as much as a dollar in the future," or the idea of time value of money. This in essence is discounting. However, the concept of discounting is not as intuitively obvious as it seems. Many people confuse this concept with inflation. Although inflation does devalue the worth of a dollar, it is a totally separate issue from discounting. To draw an analogy, suppose a person owns a house and allows another person to live in it. The owner would expect compensation for the use of his home. This compensation is usually achieved from charging rent. Discounting is much the same thing. It is the "rent" one would expect from another person for use of one's dollar.

Although the concept of discounting, as just explained, is relatively straightforward and has gained wide acceptance in the private sector, its application within the federal government has been less clearly defined. Opinions on this subject range the whole gamut, from those who say it should never be used to those who say all decisions should consider discounting. For example, Commander Clark has argued that budget constraints cause discounting

to become an irrelevant requirement in the decision process. Others, like Dr. Thaler, contend that failing to use discounting in the decision-making process will lead to the misallocation of government funds. This thesis attempted to explore the use of discounting in the acquisition process and tried to determine if, in fact, it had an impact on the outcome of decisions.

Summary of Interviews

Ten cost analysts were interviewed from Air Force Systems Command and Air Force Logistics Command. The questions asked are found in Chapter III. The first three questions are self-explanatory and will not be summarized here.

Question 4: Is discounting used to evaluate alternatives?

The intention of this question was to determine if interviewed analysts considered the impact of discounting on alternatives. Seven of the ten analysts interviewed said they had used discounting to evaluate alternatives. However, two of these seven said they only used this technique when it was mandated by regulations. The three analysts that did not use discounting were from Systems Command.

Question 5: Are operating and support costs considered when deciding among alternatives?

All ten analysts gave an affirmative answer to this question. As indicated with the Advanced Tactical

Fighter, operating and support cost are becoming increasingly more important.

Question 6: Are these operating and support costs discounted during this comparison?

Seven analysts said they did discount operating and support costs. The three analysts that said they did not use present value analyses and did not discount O&S costs, were at Systems Command staff level.

Question 7: Are decisions made based on the constant dollar comparison or present value (discounted costs) comparison?

The seven analysts that did use discounting said that present value was used to make decisions. However, it should be pointed out that cost is not the sole criteria for all decisions. Weapon system effectiveness and politics can also play an important role in any decision. Constant dollars are used for budgetary decisions.

Question 8: Does discounting effect reliability and maintainability decisions on new weapon systems?

None of the analysts said they had used discounting for reliability and maintainability decisions. However, one analyst did indicate that the tradeoff studies being done by contract on the ATF are using base year dollars. One analyst from Systems Command indicated that not enough information was available in the early stages of a weapon system to use discounting.

Question 9: What discount rate is used?

All analysts said that they would use the 10 percent discount rate, as prescribed by AFR 178-1, when performing a present value analysis. However, at least four analysts said that this rate was unrealistic and felt that it was too high. Of these four, two were from Systems Command and two were from Logistics Command.

Question 10: Do you discount constant or current (inflated) dollars?

All said that they discounted constant dollars. Current dollars were discounted only for sensitivity analyses.

Actual cases will now be examined to determine if discounting can affect decisions.

Life Cycle Cost

Life cycle cost (LCC) management is an acquisition strategy used by the Department of Defense to ensure the procurement of weapon systems which meet the operational needs of the Air Force at the lowest life cycle cost (15:1). To make intelligent decisions between alternatives, it is necessary to look beyond the immediate costs of developing and producing a system. Operating and support costs must also be considered since these costs may far outweigh initial acquisition costs. A system's LCC includes its development, production, operating and support, and disposal costs, as depicted in Figure 2. Air Force

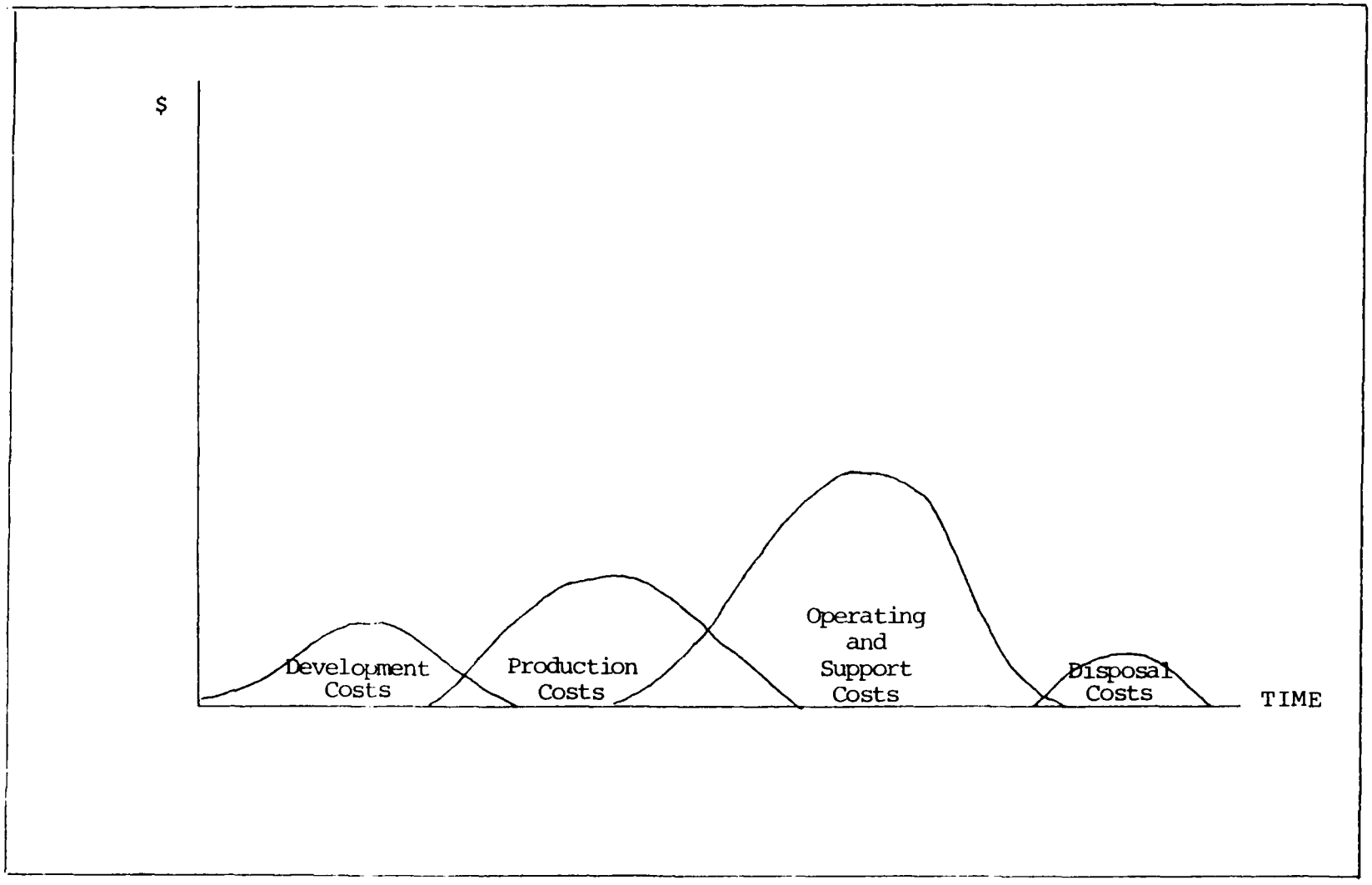

Fig. 2. A System's Life Cycle Costs (8:2-4)

Regulation 800-11 mandates that LCC be considered at all levels of command as an integral component of the decision-making process (12:1).

The concept of life cycle cost came into being in the early 1960s as a result of increasing concern over the consequences of competitive procurement without regard to total system cost (15:1). Before this time, emphasis was placed on unit production cost while life cycle cost impacts were only considered. This occurred because of the inability of program managers to predict and measure total operating and support costs. There was little motivation for program managers and contractors, to trade future savings on lower "predicted" operating and support costs for near term "known" higher unit production costs. Today, as projected defense budgets shrink, while the cost of acquiring, operating and supporting weapon systems rise, the concept of LCC is becoming increasingly important. In fact, cost has become a principal design parameter.

Life cycle cost management has two main objectives. First it establishes cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of weapon systems, subsystems and components(13:5). This objective establishes cost as an <u>active</u> rather than a <u>resultant</u> parameter. Cost must now be considered as much a technical challenge to the people involved with design

and development as performance and capability have been in the past.

> Acquisition managers must be aware of and control cost in all phases of the program and be prepared to consider the effects on cost before making each program decision [13:5].

The second objective of life cycle cost management is to establish cost elements as management goals for acquisition managers and contractors. These goals help achieve the best balance between life cycle cost, acceptable performance and schedule (13:5). Funds are becoming more critical each year as Congress cuts the defense budget. Therefore, program managers must establish these goals and manage them to prevent cost overruns and to control spiraling costs in the future.

Discounting plays an integral role in life cycle costing and decision making. This is especially true when choosing between alternatives. After determining the life cycle costs of two alternatives, two questions immediately arise:

> 1. Are the anticipated costs, which are expressed in constant dollars throughout the lives of the competing equipments, directly comparable?
> 2. Is it really worthwhile to spend a greater amount initially to save more at some future date [22:42]?

Both these questions bring up the concept of the time value of money or discounting. In answer to the first question, it is reasonable to assume that anticipated costs for two competing systems with varying designs, will differ

throughout their lives. Therefore, as long as costs are expressed in constant dollars, they are not comparable. In answer to the second question, constant dollars fail to consider the opportunity costs associated with the different system designs. If no assessment is made of these opportunity costs, there is no way to determine if it is worthwhile to buy a higher priced system in hopes of realizing decreased costs in the future.

Although it makes sense to use discounting when making decisions that impact life cycle costs, much controversy still clouds this issue (as previously discussed). The remainder of this chapter will concentrate on where discounting is actually being used in the acquisition process and what effect, if any, it has on decisions.

Operating and Support Costs

As just discussed, operating and support (O&S) costs can make up the most significant portion of a system's LCC. In order to lower future operating costs, program managers must make tradeoff decisions between higher procurement costs or higher LCCs. This is illustrated in Figure 3. Reliability and maintainability are the principle drivers of O&S costs; therefore, program managers are often faced with making choices between the two.

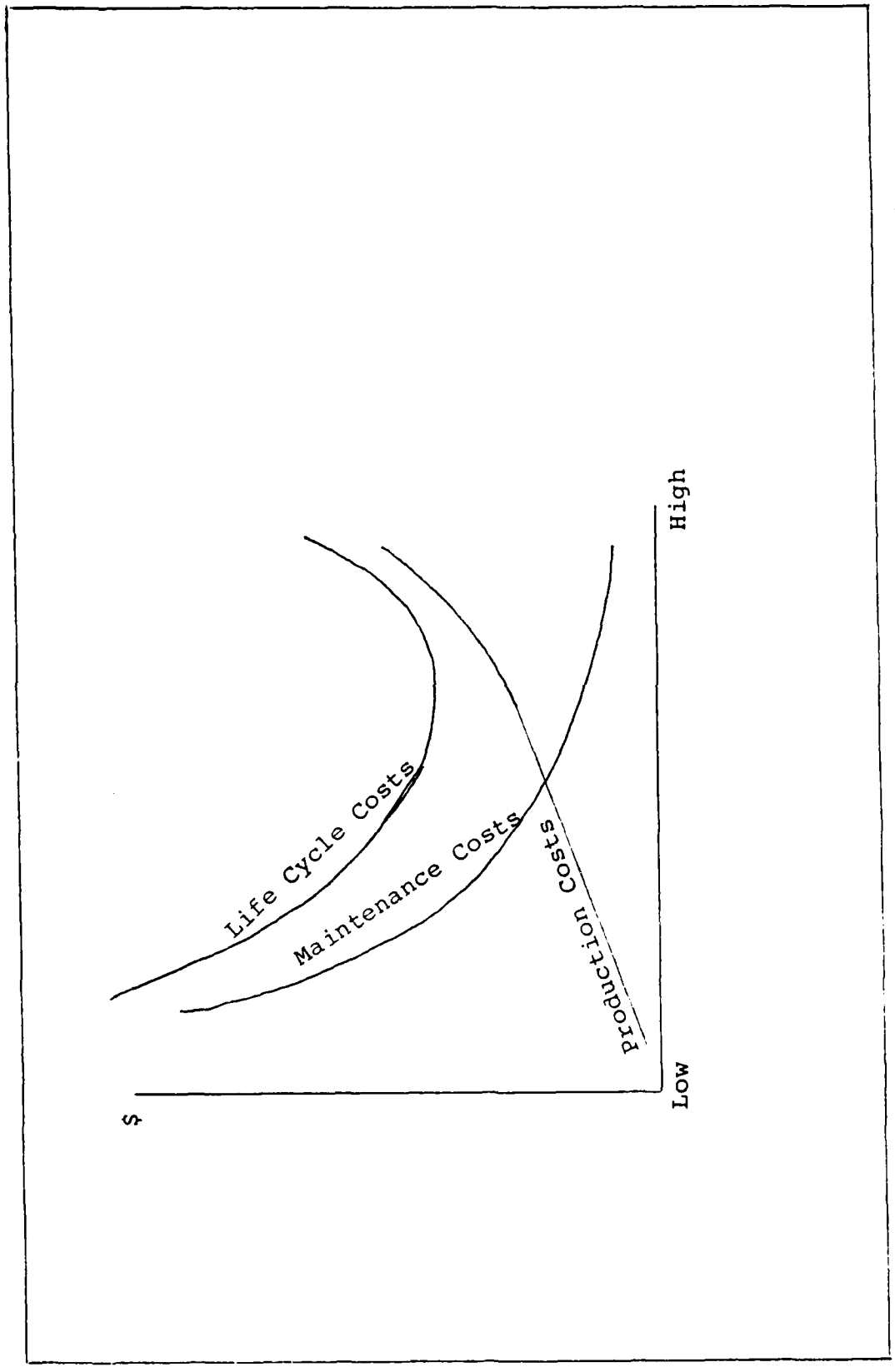

Fig. 3. Life Cycle Cost as a Function of a Design Characteristic Such as Mean Time Between Failure

Reliability deals with the amount of time a system operates to standards before failing. A more formal definition is:

> Reliability is defined as the probability that a system can meet an operational requirement for a given period when the system operates under certain conditions [9:4.3].

Reliability is measured by the amount of time that elapses between failures; also known as the mean time between failures or MTBF. Consumers have always been concerned with reliability; that is why manufacturers offer warranties on their products. For example, Chrysler's 5-Year, 50,000-mile warranty. The government is particularly interested in reliability because it directly impacts the effectiveness of the defense forces on hand.

> The difference between military victory and defeat often rests on a balance of power determined by the availability of weapon systems. Reliability is a dominant factor of availability [9:4.1].

The flip side of reliability is maintainability. Maintainability deals with downtime or the ease which one can repair a system when it fails.

> Maintainability is defined as the probability that a system can become operational within a given period when maintenance is performed by certain prescribed procedures [9:4.3].

Maintainability is measured by the amount of time it takes to repair a system. This is referred to as the mean time to repair or MTTR. Like reliability, maintenance impacts the availability and effectiveness of our defense forces.

Since World War II, the cost and complexity of new defense systems has increased, while the ability of the government to purchase and affordably maintain them has decreased. Therefore, the total quantity of systems in the defense inventory is dwindling. This makes it critical for acquisition managers to design and purchase weapons that minimize downtime so as not to adversely affect the effectiveness of our defense.

Maximizing reliability and maintainability directly ties in with the concept of LCC management. Ideally, if both could be maximized, this would lower O&S costs which in turn would lower life cycle costs. However, just as there is a tradeoff between O&S costs and procurement costs, a tradeoff must be made between reliability and maintainability.

> Both contribute to the availability or the combat readiness of a weapon system. Efforts to improve availability by increasing the mean time between failure eventually reach a point of optimum return for cost. Beyond this point, an increase of one increment of reliability is realized only by a disproportionate increment of cost. In such cases, a trade-off between reliability and maintainability may increase overall performance most satisfactorily [9:5.1].

In other words, there is a point of diminishing returns, where increasing the systems reliability slightly can only come about with a great increase in its acquisition cost. Since making these decisions requires the evaluation of different cash flows over a period of time, alternatives implementing various combinations of reliability,

maintainability and initial acquisition cost, cannot be directly compared. Therefore, discounting must be used. Theoretically the "right mix" of reliability and maintainability can be influenced by using discounting. This is demonstrated in the following example taken from QMT 353, Introduction to Life Cycle Costing Course.

Little Max

All over the Air Force bases are experiencing difficulties with a piece of support equipment called the Pitot-Static Leak Tester, or "Little Max." It checks the pitot and static air pressure and flow lines for leaks, but has been experiencing critical maintenance and supply problems. The Air Force cannot keep them in the field. Aircraft have been grounded with Not Mission Capable classifications because the "Little Max" machines have not been available to check the air pressure measurement systems.

The Air Force commissioned a study of the Little Max by Grumbling and Lockhorns, two major aerospace contractors: they joined forces to develop an LCC model which is sensitive to design parameters. They performed some initial feasibility studies and then used a modified version of their model to predict costs for a proposed 2,000 unit buy of equipment to replace Little Max (10).

The right combination of MTBF and MTTR must be chosen to ensure the lowest life cycle cost. The MTTR

can range anywhere from 5 to 12 hours, while the MTBF can range from 100 to 800 hours. The cost for different combinations of MTBF and MTTR are then calculated as shown in Table 6. Note that not all possible combinations of MTBF and MTTR have been shown; however, all were considered for the solution of this case. If costs were kept in constant dollars, the lowest cost combination would be a MTBF of 500 hours and a MTTR of 7 hours. However, if costs were discounted to their present value, the lowest cost combination would be a MTBF of 250 hours and a MTTR of 6 hours. This example shows that discounting can influence design parameters.

Advanced Tactical Fighter

Although discounting can influence the design parameters in tradeoff studies, no actual cases were found employing discounting in this capacity. However, the idea of paying higher acquisition prices initially for lower operating and support costs later on, is in practice. According to a cost analyst for the ATF program, the main objective of the ATF is to reduce the O&S costs currently being experienced with the F-15. The proposed aircraft will have the following characteristics:

1. Its engines will have 50 percent fewer moving parts.

TABLE 6

LIFE CYCLE COST OF LITTLE MAX

	In Constant Dollars			
	MTBF (Hours)			
MTTR (HOURS)	250	400	500	550
6	82,955,000	82,517,500	84,306,250	87,729,000
7	85,072,000	83,196,000	82,405,500	87,292,000
8	88,666,000	85,278,000	83,646,250	88,306,000
	In Discounted Dollars			
	MTBF (Hours)			
MTTR (Hours)	250	400	500	550
6	47,563,007	52,141,883	56,667,246	59,447,546
7	48,148,448	51,809,854	54,518,489	58,135,605
8	49,543,418	52,325,281	54,461,348	58,318,734

2. Self diagnostic equipment will be installed which will eliminate one level of maintenance. Instead of three levels of maintenance there will only be two.

3. The aircraft will be lower to the ground so that maintenance workers will not require special ladders and other support equipment when working.

4. Less than 40 percent of the aircraft frame will be pure metal. This will retard corrosion and lessen the need for repainting.

5. Black box technology will be replaced with circuit boards. This will greatly reduce the MTTR of aircraft and its subsystems (28).

Currently, tradeoff studies are being conducted to ensure the feasibility of these proposals. Although not available due to their classification, all studies are done in base year dollars. The base year for the ATF is 1985. The Air Force is expected to purchase 750 aircraft at an average cost of 35 million dollars. Although this acquisition cost is higher than the F-15, its operating and support costs are projected to be lower.

T56-15 Engine Evaluation

As mentioned previously, discounting can be used to evaluate two mutually exclusive alternatives. In essence this is what an economic analysis (EA) does. DODI 7041.3 defines an EA as:

> A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner [13:2].

EAs are typically used to evaluate military construction projects; however, they can be used to determine if an acquisition program should be undertaken.

An example of this is a recent evaluation accomplished by HQ AFLC and SA-ALC to determine whether or not all C-130B/Es should be upgraded with the T56-15 engine. Currently there are two different engines being used on the C-130B/E, the T56-7 and the T56-15. The T56-15 is the newer of the two engines. These engines are not interchangeable and require separate maintenance programs. In other words, a crew chief knowledgeable only on the T56-7 engine could not fix a T56-15 engine. Military Airlift Command (MAC) would like to convert all T56-7 engines to the newer T56-15 engine. By doing this they would eliminate the need to keep two inventories of spare parts, two different sets of technical orders and two different training programs. In addition, they feel mission effectiveness would be improved.

MAC is hoping that the savings realized by standardizing the C-130B/E fleet with the T56-15 engine, will more than offset the initial acquisition cost of $550M. To determine this, a savings to investment ratio (SIR) must be calculated. A SIR requires that the analyst track

the successive accumulation of discounted operating and support savings of the proposal for its economic life. An investment is said to break even when its operating and support savings equal the initial investment. As this equality is approached, the savings to investment ratio will rise from a small fraction to a value of one. In general, the higher the SIR, the quicker the payback and the more appealing the proposal.

$$SIR = (I-V)/S \tag{5}$$

where

I = Discounted initial investment

V = Discounted terminal value

S = Total discounted savings

To solve for a SIR two areas must be quantified: (1) the cost of the investment, and (2) the resultant savings. To determine these quantities an economic analysis was accomplished. In this case, two EAs were prepared. One was done at the San Antonio Air Logistics Center (SA-ALC) and the other was prepared at Headquarters Air Force Logistics Command at Wright-Patterson Air Force Base (HQ AFLC). Table 7 shows the discounted LCC savings for the proposed T56-15 engine, for both EAs. The results of these two studies were drastically different. HQ AFLC estimated savings nearly three times higher than SA-ALC's

TABLE 7

DISCOUNTED LCC SAVINGS (24:4)
(87$ M)

	Depot Maint	Base Maint	Trans	Tech Data	Sust Inv	Fuel	Total
SA-ALC	90.8	32.7	0.6	0.5	25.6	32.4	182.6
HQ AFLC	269.7	170.6	3.1	0.5	69.9	27.1	540.9

estimate. Different methodologies and assumptions account for these conflicting results and will be discussed.

SA-ALC prepared the initial EA on the T56-15 engine and sent it to HQ AFLC for verification. Obviously, HQ AFLC did not agree entirely with the methodology or assumptions made by SA-ALC. HQ AFLC made three basic methodology changes. First they added a year of VAMOSC data to the information from which projections were made. The second thing they changed was the cost basis, from cost/engine to cost/engine flying hour (EFH). Finally, they assumed the same economic life for both the T56-7 engine and the T56-15 engine.

The SA-ALC study only used FY85 VAMOSC data for estimating depot maintenance, I-level or intermediate maintenance, sustaining investments, and fuel. HQ AFLC expanded this base to include both FY84 and FY85 data. The intent was to include as much history as possible in the baseline. Data prior to FY84 was not used, due to the severe parts

shortages and unusual maintenance practices, such as cannibalization, experienced during that time.

> In the SA-ALC study, the basic methodology for computing savings for depot and I-level maintenance, sustaining investments and fuel was to first compute a cost/engine for the T56-7 and T56-15 engines. This was done by taking the corresponding engine support cost reported in VAMOSC and dividing it by the total number of engines (both installed and uninstalled). The arithmetic difference between the cost/engine for the T56-7 and T56-15 was termed the expected saving/engine by upgrading to the T56-15 engine. This savings/engine was then multiplied by the number of T-56-15 engines required to support the C-130B/E fleet to get the total savings for that cost category [24:3].

HQ AFLC, on the other hand, used a cost/EFH basis for figuring savings. To apply this method they developed an average cost/EFH for both the T56-7 and T56-15 engines based on the combined FY84 and FY85 VAMOSC data. The projected engine flying hours was estimated at 840,000/year and was used for all years. A total cost was then computed by multiplying the cost/EFH (in FY87$) by 840,000. The arithmetic difference in the total cost for each engine was used as the estimated savings.

The final change dealt with the economic life of both engines. SA-ALC's analysis assumed a 20-year life for the T56-15 engine but an indefinite life for the T56-7 engine. This assumption, to say the least, is unrealistic. The T56-7 engine, along with its associated support costs, were not phased out. This gave the appearance of extra savings in years 21 to 25 for the T56-15 engine (because there were no support costs during these years for this

alternative). HQ AFLC assumed both engines had the same 20-year economic life. They further assumed that both engines would have identical terminal values; therefore, there would be no net savings. The total discounted value of the investment for the T56-15 engine was adjusted to $499,143,503.

These differences in methodology accounted for the major discrepancies between the two analyses. HQ AFLC computed a SIR of 1.08 ($540M/$499M). The payoff in this analysis occurs around year 18.5. SA-ALC's analysis, on the other hand, calculated a SIR of .37 ($182/$499) and concluded that the initial investment did not pay back within its economic life. Although these two studies resulted in different conclusions, both used present value analysis to arrive at them. If discounting had not been used, the calculated SIRs would be much higher. For instance, the SIR for HQ AFLC in constant dollars would be 2.36 (1297/550) and it would pay back in 7.5 years.

A decision on this investment has not been made. Other considerations besides cost, such as mission effectiveness, must be taken into account. However, MAC was trying to "sell" this program on savings alone. If discounting was not used, this would be a much easier task. Failure to use discounting, on the other hand, would lead to a less than optimal distribution of Air Force funds if other investments existed with quicker payback periods.

Multiyear Versus Annual Buy

The T56-15 engine analysis clearly shows how discounting can influence decisions and how different assumptions and methodologies can effect present value calculations. Unfortunately, according to Bob Novak of AFLC/ACCCE, preparer of this case, these types of analyses are the exception, not the rule. One area that mandates the use of discounting is multiyear versus annual-buy decisions. Congress requires that a present value analysis be done on each multiyear candidate.

> The multiyear procurement general provision has been modified to require that each negotiated multiyear contract have a positive present value savings before execution. . . .
> The Committee recommends a new requirement for a present value analysis in the comparison of multiyear and annual procurement cost (Senate Appropriations Commiteee Report in 1986 DOD Appropriation Bill, pp 94-95 and 346-347) [18].

> Provided further, that the execution of multiyear authority shall require the use of a present value analysis to determine lowest cost compared to an annual procurement (Public Law 99-190 (Continuing Resolution for 1986, Sec. 8037; Identical language in Public Law 99-500, FY87 Appropriations, Sec. 9032) [18].

One such analysis was recently accomplished on the IR Maverick missile. The Air Force plans to purchase 48,644 IR Maverick missiles over nine fiscal years, using two multiyear (MY) contracts. Table 8 shows the planned quantity of missiles to be purchased, by year, under the first MY contract. It also shows the corresponding cash flows for both multiyear and annual-buy strategies. Notice

TABLE 8

PRESENT VALUE ANALYSIS--AIR FORCE IR MAVERICK MISSILE
($ in Millions)

	Outlays								Multiyear
	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	Total
	Quantity								
	1900	2700	4400	4800	-	-	-	-	13800
Annual Contract									
Then Year Dollars	29.3	108.9	239.4	353.0	381.2	284.2	115.2	24.3	1535.5
Constant Dollars	29.3	105.4	225.2	324.2	341.9	249.1	98.6	20.3	1394.0
Present Value	26.6	87.1	169.1	221.4	212.3	140.5	50.6	9.5	917.1
Multiyear Contract									
Then Year Dollars	39.6	135.2	261.2	320.8	299.2	206.8	81.4	17.2	1361.4
Constant Dollars	39.6	130.9	245.7	294.6	268.3	181.2	69.7	14.4	1244.4
Present Value	36.0	108.1	184.5	201.2	166.6	102.2	35.8	6.7	841.1
Difference									
Then Year Dollars	-10.3	-26.3	-21.8	32.2	82.0	77.4	33.8	7.1	174.1
Constant Dollars	-10.3	-25.5	-20.5	29.6	73.6	67.9	28.9	5.9	149.6
Present Value	-9.4	-21.0	-15.4	20.2	45.7	38.3	14.8	2.8	76.0

NOTES: Constant Year = FY89; Constant year dollars based on Dec 1986 OSD raw inflation rates--3020 Appropriation; Present values calculated using 10 percent end-of-year discount factor.

that the multiyear contract requires a greater investment up front than the conventional annual-buy contract. The only way to determine if these extra expenditures in the early years are beneficial, is to conduct a present value analysis. By discounting both cash flow streams, the total cost of both contracts can be compared in today's dollars.

The quickest way to determine if the multiyear contract will pay off, is to look at its present value. If the present value is greater than zero, the program technically passes the "litmus test." For practical purposes, however, this number should be significantly higher. The higher the number, the better.

> The higher the number, the more attractive the investment from a strictly financial point of view.
> The higher the number, the higher the confidence that the investment will actually be worthwhile. In other words, the higher the number, the more remote the possibility that it could "go negative" if actual then-year multiyear savings turn out to be lower than the preliminary estimate you are now working with [17].

The present value of the Maverick multiyear contract is 76. Considering this alone, one would conclude that it was the best procurement option. Table 9 shows a summary of savings. However, there are other considerations. As alluded to previously, the numbers on which this analysis is based are predictions and subject to change. Since the Maverick missile has been in production for some time (this program is a modernization of the TV Maverick), the risk associated with these costs changing significantly is

TABLE 9

ACQUISITION STRATEGY COMPARATIVE SUMMARY--AIR FORCE
IR MAVERICK MISSILE MULTIYEAR VERSUS ANNUAL BUY
($ in Millions)

	Annual Contracts	MYP Alternate
Number of Units	13,800	13,800
Total Contract Price	1535.5	1361.4
$ Cost Avoidance over Annual	-	174.1
% Cost Avoidance over Annual	-	11.0%

low. On the other hand, this buy is broken into two contracts. The present value calculation is based on the assumption that if the first multiyear contract is approved, the second contract will also be approved. If this assumption is false and the second MY contract is not funded by Congress, the actual present value of the first contract is -25.6. Although nonapproval of the second contract is not likely, it is always a possibility.

The primary benefit of the Maverick MY contract will be to reduce unit costs. However, there are other benefits that should be considered. First, seventeen countries bought TV Mavericks under Foreign Military Sales (FMS). The IR Maverick is attractive to them because of similar support requirements and because there isn't a need to modify aircraft which can carry TV Mavericks. Many of the

seventeen countries and others are considering FMS purchases of the IR Maverick. The MY contract will reduce unit costs, and make an attractive purchase even better. Secondly, a MY contract will stabilize production levels. This, in turn, will result in stable employment, continuous labor learning, and the potential to economically use higher skill levels. Finally, a MY contract will result in steadier more predictable cash flows that will allow the contractor to use economic order quantities when purchasing components from subcontractors.

Break-even Analysis

Multiyear procurements are just one method the Air Force is using to reduce unit costs of new weapon systems. Competition is another method. Competition can be increased by dual sourcing or by second sourcing. In dual sourcing, two manufacturers are given specifications and told to build a system that meets them. A fly-off is then conducted with the best design winning the contract. In second sourcing, one manufacturer is already producing the system. The government can introduce a second source into the market by providing the technical drawings for the system being manufactured and having this new source produce a like system.

Whenever a second source is established considerable expenses are incurred. First, the Air Force must

determine if the company is qualified to manufacture the system. It must decide if the company has the skilled labor, equipment and capacity to build the system. Production lines must be set up and the first units produced. The first units of any system are always more expensive because no learning has taken place and "bugs" on the production line are still being worked out. As more units are produced, unit costs decrease because learning is taking place. The Air Force must bear the expense of these first units.

Programs selected for second sourcing must have the potential to generate enough savings to offset the initial start-up costs. The IR Maverick missile was one program selected for dual sourcing. In November 1976, the Deputy Secretary of Defense directed that a second source for the production of the IR Maverick be established. At the time, Hughes was the sole producer of the system. In May of 1983, Raytheon was awarded a contract to build the IR Maverick missile.

Managers had to determine if the extra costs associated with the first production units from Raytheon would be recouped by future savings. A break-even analysis was accomplished to determine this. Using present value it was determined that 44,813 missiles would have to be produced by Raytheon for this decision to break even (see Table 10). It should be noted that since the contract

TABLE 10

COMPETITION SAVINGS
(TY$M)

	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	Total
Total Quantity	1100	1980	2600	3500	5700	10200	12000	12000	11584	0	60664
Raytheon Qualification	-65.3	-	-	-	-	-	-	-	-	-	-65.3
Raytheon Tooling	-	-	-	-	-19.6	-10.1	-11.3	-	-	-	-41
Raytheon Eng & Mgt	-	-	-	-	-19.6	-20.6	-21.5	-22.4	-23.4	0	-107.5
Premium Cost of Raytheon Units	-	-	-	-106.4	-66.6	-	-	-	-	-	-173
Gross Savings	-	-	-	-	0	119.6	137.1	137.7	136.5	0	530.9
Net Savings	-65.3	0	0	-106.4	-105.8	88.9	104.3	115.3	113.1	0	144.1

TABLE 10--Continued

	Net Present Value Calculations										
	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	Total
FY (Net Savings from Above)	*	-	-	-106.4	-105.8	88.9	104.3	115.3	113.1	0	144.1
multiplied by the discount #	**	-	-	0.9090	0.8264	0.7513	0.6830	0.6209	0.5644	0.5131	-
Net Present Value of Savings	0	0	0	-96.7	-87.4	66.8	71.2	71.6	63.8	0.0	89.3
	Break-even Quantity										
	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	Total
Break-even Point (TY$ Savings)	1100	1980	2600	3500	5700	10200	12000	8774	0	0	45854
Break-even Point (NPV Savings)	1100	1980	2600	3500	5700	10200	12000	7733	0	0	44813

*The Raytheon Qualification cost of $65.3M is considered to be a sunk cost, and is therefore not included in the net present value calculations.

**The discount # is $1/(1+k)^n$ where k is the cost of capital (10 percent per AFR 178-1), and n is the number of years from FY85.

had already been awarded, the Qualification Program (initial start-up costs) of 65.3M was considered a sunk cost and not included in this analysis. Had these costs been considered, the break-even point would not have been reached. The DoD, in this case, was interested more in expanding the industrial base than future savings.

Lease Versus Buy Decisions

Lease versus buy decisions differ from other present value analyses, in that the asset and project have been identified (and thus future investment and consumption streams determined) and therefore, the consideration at issue is cost alone (11:20). In these types of decisions, the assumptions made and the discount rate used can greatly influence the outcome. AFR 178-1 states:

> The discount rate in lease versus buy analyses should be the current interest rate on Treasury securities whose maturity most closely corresponds to the length of the lease, plus one-eighth of one percentage point [11:20].

This regulation also states that inflation should be considered in any analysis. One lease versus buy decision involved the C-21 Learjet.

This case is somewhat unusual in that the Air Force already had a lease agreement with Gates Learjet. The contract allowed the Air Force (AF) to lease 80 jets for five years; at the end of this time period the AF had the option of buying the aircraft or extending the lease an additional

three years, at which time the AF could either purchase the aircraft or terminate the contract. The AF was leasing the planes for less than $10M a year, but this arrangement was costing Gates Learjet as much as $1 million a month. Needless to say, a year of this negative cash flow put the company in financial difficulties. At this point various members of Congress began to pressure the Air Force to buy the aircraft (6).

A lease versus purchase analysis was conducted to determine a purchase price that would be equitable to all parties. A 13.3 percent discount rate was used: 10 percent real rate adjusted for an assumed 3 percent inflation. Tables 11 and 12 show the respective results for purchasing the C-21 after five years and eight years. The best alternative for the Air Force would have been to purchase the aircraft after eight years for 2.081 million dollars. Unfortunately, Gates Learjet would have been out of business by then. Instead, the 80 jets were purchased in 1986 at a price of 2.2 million per aircraft (6).

Conclusion

Discounting is being used in the acquisition process, although currently its use is somewhat limited. The cases just examined show how discounting can play a role in determining design characteristics, system purchase decisions, multiyear versus annual-buy decisions and,

TABLE 11

PURCHASE NOW VERSUS C-21 FIVE-YEAR OPTION--13.3 PERCENT DISCOUNT
($ Mil)

Alternatives	Price Paid Now (per Unit)	Present Value Purchase Now	Lease/Buy	(+) Advantage/(-) Disadvantage if Purchased Now
Market Price	2.400	192.00	183.36	-8.63
Economic Purchase Price	2.299	183.92	183.36	0
Market Price	2.250	180.00	183.36	+3.36
Congress Suggested	2.200	176.00	183.36	+7.36

TABLE 12

PURCHASE NOW VERSUS C-21 EIGHT-YEAR OPTION--13.3 PERCENT DISCOUNT
($ Mil)

Alternatives	Price Paid Now (per Unit)	Present Value Purchase Now	Lease/Buy	(+) Advantage/(-) Disadvantage if Purchased Now
Market Price	2.400	192.00	166.48	-25.51
Offered	2.299	183.92	166.48	-17.43
Congress Suggested	2.200	176.00	166.48	-9.51
Achieve 10% Real at 3% Inflation	2.081	166.48	166.48	0

finally, lease versus purchase decisions. This list by no means represents all the decisions under which discounting is appropriate. In general, discounting should be used to evaluate alternatives with different cash flows.

These cases also demonstrated how present value analyses can be affected by the assumptions made by the analysts. Some of these assumptions include: the type of methodology being used, as in the T56 engine; the assumed economic life of the system, again the T56 economic analysis demonstrated this; and the rate of inflation used, as seen in the C21 case. In addition, the discount rate used by the analyst can affect the outcome of these decisions. The AF, however, has mandated that a 10 percent rate be used. This rate was criticized by several analysts interviewed as being too high but agreement on any alternate number may prove difficult.

V. Conclusions

Summary, Conclusions and Recommendations

The Gramm-Rudman ax has begun swinging and the deepest cuts are sure to be felt in the defense budget. Because of this, DoD must judiciously allocate its diminishing funds. One technique that helps managers make educated choices between alternatives is discounting. Discounting allows managers and analysts to directly compare two or more alternatives with different cash flows. Its use has been well established in military construction and productivity enhancement projects. However, the use of discounting in the acquisition process is less well defined. This thesis attempted to determine if discounting is being used during the acquisition process and what affect it had on decisions.

Several analysts were interviewed and cases studied to determine if and where discounting was being used in the acquisition process. Although one can conclude that discounting is being used, it is not a widespread technique. Discounting can be used in all phases of the acquisition process, from determining design characteristics to determining production runs. The use of discounting is appropriate whenever alternatives are being compared with different

cash flows. Currently, however, it seems that discounting is only used on well established programs where future costs are easily predicted. For example, the T56-15 engine has been in the AF inventory for over ten years. It has a well established data base in the VAMOSC system. The Maverick Missile is in its second production run; therefore, it has a well established basis for predicting future costs. Finally, the C-21 analysis did not consider maintenance costs, only acquisition costs. Discounting should not be limited to decisions affecting systems with established data bases.

Life cycle costs of weapon systems are becoming increasingly important to the Air Force. When dealing with LCC the major component is often maintenance costs. Maintenance costs are driven by the mean time between failures (MTBF) and the mean time to repair (MTTR). As demonstrated by the Little Max case study, discounting can affect the optimal mix between these two design characteristics and in turn alter a systems operating and support costs. Although proven in theory, actual cases where discounting was used to determine the design characteristics of a new system were not found.

The premise for using discounting in the specification and design phase, is that decisions made early in a weapon system's development will have greater cost implications than those made later in the system's life

cycle. Most of these early decisions are easy to make since few constraints are imposed at this stage. In theory at least, a system that considers discounting during its design phase can have completely different characteristics than a system that fails to consider discounting. One can only speculate on the effect discounting would have on defense if it were used on all weapon systems.

Discounting has been used in "go, no go" decisions. For example, the decision by MAC to refit all C-130B/E aircraft with the new T56-15 engine. MAC had to determine if the net saving from this action would justify its initial acquisition cost. This case also demonstrated how differences in methodology can affect the outcome of an analysis. There are some decisions where the Air Force mandates the use of discounting. In the acquisition process, this includes multiyear versus annual-buy decisions. For the most part, however, discounting is not widely used. Finally, it was shown that costs are not always the only consideration when choosing between alternatives; non-cost can play a significant role as demonstrated by the C-21 case.

Discounting can affect the outcome of decisions. On the T56-15 engine, using current dollars would make the investment appear to pay off sooner. Using discounting on the Maverick Missile second sourcing decision, makes it harder to justify the initial start-up expenses

associated with establishing a second source. Finally, not using discounting in the C-21 analysis would make purchasing appear more cost effective than leasing. The use of discounting could clearly affect defense decisions.

Discounting is a useful tool and should be utilized in any decision requiring the comparison of alternatives with different cash flows. Air Force regulations should mandate that discounting be used in any decision having these characteristics. In addition, analysts should realize that discounting can be used at any stage in the acquisition process and that decisions made earlier in a weapon system's life will carry the greatest cost impact. The use of discounting will lead to a better allocation of diminishing government funds.

Recommendations for Further Study

The debate surrounding the use of discounting in the public sector has been ongoing for more than 20 years, and it is unlikely that the differences in opinion will ever be completely resolved. However, discounting is being used in the public sector and it will continue to be used. The discount rate utilized in these analyses greatly influences the outcome. The 10 percent discount rate mandated by the government was questioned by several analysts interviewed in this study. All who questioned it felt the rate was too high. Research in this area to

determine the origin of the 10 percent rate and to determine what rate should be used, is warranted. In addition, productivity enhancement projects (A-76) were not addressed in this thesis; however, the methodology behind these analyses was questioned in several interviews. A thesis could be done on the methods used in A-76 studies. Finally, the question of whether design choices would differ if discounted cost were considered, still remains. A study on how design characteristics are determined and what affect discounting would have if considered would be beneficial. Further studies in these areas would be very helpful in improving the effectiveness of public investment analysis in both DoD and the government as a whole.

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Block 19--Abstract

The technique of discounting is based on the premise that a dollar today is worth more than a dollar in the future. This is often referred to as the time value of money. This technique is widely accepted in the private sector; however, its use in the public sector has been repeatedly questioned. This thesis explores the use of discounting within the Air Force, specifically within the acquisition process. Several analysts were interviewed and several cases were reviewed to determine if discounting is being used and how it affected the outcome of decisions. In addition, the author provides a background behind the discount rate being used by the DoD, including a discussion on the social discount rate theories, the difference between net present value and internal rate of return, and a discussion on inflation.

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